CHAPTER 1
INTRODUCTION

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1.1. Background

The South Coast Air Basin (Basin), a highly urbanized area in southern California, is home to about 17 million people and about 11 million motor vehicles. The Basin contains some of the highest concentrations of industrial and commercial operations in the country. Air quality in the Basin is typically the most polluted in the U.S. The Multiple Air Toxics Exposure Study (MATES) is a unique environmental justice program that has spanned more than three decades and provides a detailed assessment of the impacts of a group of air pollutants known as “air toxics”, which are pollutants that can cause important health effects. Unlike the common “criteria air pollutants”, there are no state or federal standards for air toxics. Examples of air toxics include gases, such as benzene and 1,3-butadiene, as well as particles, such as arsenic and diesel particulate matter. The South Coast AQMD has several programs that are designed to reduce air toxics emissions, which provide public health benefits. State and federal regulatory agencies also work to reduce air toxics from a variety of sources, such as diesel trucks, locomotives, and ships.

In 1986, South Coast AQMD conducted the first MATES analysis to determine the Basin-wide risks associated with major airborne carcinogens. At the time, technological limitations only allowed for measurements of 10 known air toxic compounds. In 1998, a second study (MATES II) became one of the most comprehensive air toxics measurement programs conducted in an urban environment. MATES II included a monitoring program of 40 known air toxic compounds, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize health risks from hazardous air pollutants. A third study, MATES III, was conducted in the 2004-2006 timeframe. It consisted of a two- year monitoring program as well as updates to the air toxics emissions inventory and a regional modeling analysis of exposures to air toxics in the Basin. A fourth study, MATES IV, was conducted in the 2012-2013 timeframe. It consisted of a one-year monitoring program as well as updates to the air toxics emissions inventory and a regional modeling analysis of exposures to air toxics in the Basin.

The MATES program is designed to assess overall long-term trends in air toxics levels in the community. It has long been recognized that air toxics levels vary across communities, and the MATES program provides important information to examine these differences. A health risk assessment approach helps to estimate the potential extent of health impacts from these air toxics. In the MATES analysis, the health risk assessment evaluates chronic (long-term) non-cancer health risks as well as cancer risks from air toxics. Although MATES is not able to evaluate acute non-cancer health risks, other South Coast AQMD programs, such as the AB 2588 Air Toxics Hot Spots Program, do address acute health risks. The current study, similar to the previous MATES studies, focuses on the carcinogenic risks from exposures to air toxics. Given the MATES program’s focus on air toxics, the study does not include an analysis of the health impacts from exposure to particulate matter or ozone. Studies of the health effects and impacts from criteria pollutants were summarized previously as part of the Air Quality Management

Plans.[1]

Since the MATES studies were first conducted, several emissions control programs have been implemented at the national, state, and local agency levels; and toxics emissions have been declining. However, there remains heightened awareness of toxic air contaminant exposures on a community level, that is, in areas that are close to sources of these pollutants. There are also concerns that although regulatory programs have reduced toxic emissions, the risks in environmental justice communities, which often have many sources of air toxics, continues to exceed the risks in other communities.

This report provides the results of the fifth air toxics monitoring and exposure study conducted by the South Coast AQMD. It consists of a one-year monitoring study, as well as updates to exposures and risk estimated from air toxics. The objective is to update the characterization of ambient air toxic concentrations and potential exposures to air toxics in the Basin. MATES V also aims to harness modern tools for displaying air quality information for public audiences.

The MATES results can be used to examine the trends and spatial patterns of important air toxic pollutants in the Basin, assess the overall impacts of current air toxic control measures, and help inform appropriate control strategies for reducing exposures to air toxics associated with significant public health risks. We anticipate that the results of this study additionally would serve to inform an update of the South Coast AQMD's Air Toxics control plans.

There are four main components to the study, as listed below:

- Air Toxics Monitoring and Analyses
- Emissions Inventory Updates
- Air Toxic Modeling and Risk Assessments
- Interactive Data Dissemination Tools

The Air Toxics Monitoring and Analyses portion of the study includes a fixed-site monitoring program with ten stations to characterize long-term regional air toxics levels in residential and commercial areas. In addition to air toxics, the monitoring portion of the study includes measurements of Black Carbon and Ultrafine Particles. These components are further described in the chapters that follow.

Programs such as MATES are designed to monitor and characterize toxic emissions over the entire Basin. However, ambient monitoring is conducted at a limited number of locations, and modeling provides a spatial resolution of 2 km. Communities located very near industrial sources, major transportation corridors, or large mobile source facilities (such as marine ports, railyards and commercial airports) can be affected by higher air contaminant levels than can be captured in the typical MATES analysis. Near-road monitoring studies and dispersion modeling results for point sources indicate that exposure can vary greatly over distances much shorter than 2 km. Under the MATES V program, an Advanced Monitoring Studies component was added to

[1] South Coast Air Quality Management District, "2016 Air Quality Management Plan Appendix I: Health Effects," March 2017. [Online]. Available: http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/appendix-i.pdf?sfvrsn=14 .[Accessed 12 March 2021].

provide high resolution, local-scale monitoring at or near petroleum refineries. The community areas chosen for monitoring were chosen based on proximity to these sources as well as environmental justice concerns. The results of the MATES V Advanced Monitoring Studies will be published in a separate report.

1.2. Health Effects of Air Toxics and Ultrafine Particles (UFPs)

Given the range of pollutants that are classified as air toxics, long-term exposures to these pollutants can cause a wide variety of health effects, with higher chances of health effects occurring at higher pollutant concentrations. For example, diesel PM is a known human carcinogen, with studies linking diesel PM exposure to increased lung cancer risks. Chronic exposure to diesel PM can also cause or worsen other lung diseases (including worsening asthma) and heart diseases. Benzene is also a known human carcinogen, but unlike diesel PM, the main types of cancers associated with benzene are blood cancers. Chronic benzene exposure can decrease blood cell formation in the bone marrow, which can lead to health conditions such as anemia.[2] Arsenic is a metal air toxic pollutant that can cause certain types of cancers of the lung, skin and bladder, as well as skin lesions, diabetes and high blood pressure.[3,4] All of these types of long-term health impacts are evaluated as part of the health risk assessment in MATES. Additional information about the various health effects associated with the specific air toxics evaluated in this study can be found on the Air Chemicals website (https://oehha.ca.gov/air/chemicals) developed by the Office of Environmental Health Hazard Assessment.

In addition to specific air toxics, beginning with the MATES IV study, the South Coast AQMD has measured ultrafine particles (UFPs) at the fixed monitoring stations. Ultrafine particles are typically defined as particulate matter with an aerodynamic diameter of ≤0.1µm (≤100 nm). These very small particles are formed from combustion processes, with one major source being combustion engines, especially diesel engines.[5] Other important sources of UFPs include fuel used at stationary sources, other mobile sources, meat cooking and wood burning. Toxicological studies have found that UFPs can be inhaled more deeply into the lung tissues and take a longer time to be cleared from the lungs compared to larger inhalable particles (e.g. PM2.5, PM10). UFPs can also translocate from the lungs into the blood and other organs, and can enter the brain

[2] U.S. Department of Health and Human Services, "Agency for Toxic Substances and Disease Registry, Benzene – ToxFAQs," 2007. [Online]. Available: https://www.atsdr.cdc.gov/toxfaqs/tfacts3.pdf . [Accessed 11 March 2021].

[3] U.S. Department of Health and Human Services, "Agency for Toxic Substances and Disease Registry, Benzene – ToxFAQs," 2007. [Online]. Available: https://www.atsdr.cdc.gov/toxfaqs/tfacts3.pdf . [Accessed 11 March 2021].

[4] International Agency for Research on Cancer, "Arsenic, Metals, Fibres, and Dusts (Volume 100C)," 2012. [Online]. Available: https://monographs.iarc.fr/wp-content/uploads/2018/06/mono100C-6.pdf . [Accessed 31 March 2021].

[5] Health Effects Institute, "Understanding the Health Effects of Ambient Ultrafine Particles," January 2003. [Online]. Available: https://www.healtheffects.org/publication/understanding-health-effects-ambient-ultrafine-particles . [Accessed 12 March 2021].

tissues through the olfactory nerve.[6] There is currently no federal or state standard for UFPs. In 2019, the U.S. EPA classified the weight of scientific evidence for long-term UFP exposures was suggestive of a causal effect for neurological health effects; evidence for short-term UFP exposures were also suggestive of causal effects for neurological effects, as well as respiratory and cardiovascular effects.[7]

1.3. Estimates of Risks

A health risk assessment evaluates the potential health impacts from exposures to substances released from a facility or found in the air. These assessments provide estimates of potential long-term cancer and non-cancer health risks. The assessments do not collect information on specific individuals but are estimates of potential effects in a population at large.

Potential health risks were estimated using methodology consistent with the procedures recommended in the 2015 California Office of Environmental Health Hazard Assessment's (OEHHA) "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments" (Guidance Manual).[8] As discussed in the Guidance Manual, the risk assessment process generally consists of four parts; namely hazard identification, exposure assessment, dose response assessment, and risk characterization. The risk assessment steps, as applied in this study, are briefly summarized below.

Hazard Identification

Hazard identification involves determination of whether a hazard exists; and, if so, if the substance of concern is a potential human carcinogen or is associated with other types of adverse health effects in humans. For this study, the list of air toxics in the 2015 OEHHA risk assessment guidelines[8] was used in conjunction with information on ambient levels of air toxics from previous studies, as well as input from the Technical Advisory Group, to determine which substances to focus on for this assessment. This list is provided in Appendix I.

Exposure Assessment

The purpose of an exposure assessment is to estimate the extent of public exposure for a substance. This can involve quantification of emissions from a source, modeling of environmental transport and fate, and estimation of exposure levels over some period of time. In

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[6] A. Peters, B. Veronesi, P. Calderon-Garcuduenas, P. Gehr, L. Chen, M. Geiser, W. Reed, B. RothenRutishauser, S. Schurch and H. Schulz, "Translocation and potential neurological effects of fine and ultrafine particles a critical update," *Part Fibre Toxicol*, p. 3:13, 2006.

[7] U.S. Environmental Protection Agency, "U.S. EPA. Intergrated Science Assesment (ISA) for Particulate Matter (Final Report, Dec 2019)," U.S. Environmental Protection Agency, Washington, DC, 2019.

[8] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0 . [Accessed 1 October 2020].

this study, annual averages of the air toxics of concern were estimated in two ways. For the fixed site monitoring station data, annual averages were calculated and used as an estimate of exposure, see Appendix XI for details. For the modeling analysis, emissions over the Basin and the Coachella Valley were estimated and allocated to 2 kilometer by 2 kilometer geographic grids, and a regional dispersion model was used to estimate the annual average concentrations in each grid cell.

Dose Response Assessment

The dose response assessment characterizes the relationship between exposure to a substance and the incidence of an adverse health effect in an exposed population. For estimating cancer risk, the dose-response is expressed in terms of a potency slope that is used to calculate the probability of cancer associated with a given exposure. These cancer potency factors are expressed as the 95^{th} statistical upper confidence limit of the slope of the dose response curve assuming a continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight. For non-cancer health effects, dose-response data are used to develop acute and chronic Reference Exposure Levels (RELs). The RELs are defined as the concentrations at or below which no adverse non-cancer health effects would be found in the general population. The acute RELs are designed to be protective for infrequent 1- hour exposures. The chronic RELs are designed to be protective for continuous exposure for at least a significant fraction of a lifetime.

For this study, the dose-response estimates developed by OEHHA[9] are used to estimate the potential for adverse health effects for chronic exposures. Note that these estimates sometimes differ from those developed by the U.S. EPA. For example, OEHHA has developed a cancer potency factor for diesel exhaust, whereas the U.S. EPA has elected not to do so. The U.S. EPA does state, however, that diesel exhaust is likely to be carcinogenic to humans and has adopted extensive regulations designed to reduce diesel exhaust exposure.[10] While some of the potency estimates OEHHA has developed for other air toxics produce different estimates of risks than those that would be calculated using the U.S. EPA values, the risk from diesel exhaust calculated using OEHHA's cancer potency factor is the dominant contributor to the estimated air toxics cancer risk in this study.

Risk Characterization

In this step, the estimated concentration of a substance is combined with the cancer potency factors and RELs to determine the potential for health effects. This study multiplies the estimated or measured annual average levels for potential carcinogens by the cancer potency factor, molecular weight adjustment factor, combined exposure factor, and multi-pathway adjustment factor to determine cancer risks. The molecular weight adjustment factor is only used when a

[9] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, "Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0 . [Accessed 1 October 2020].

[10] United States Environmental Protection Agency, "Learn About Impacts of Diesel Exhaust and the Diesel Emissions Reduction Act (DERA)," 2020. [Online]. Available: https://www.epa.gov/dera/learn-about-impacts-diesel-exhaust-and-diesel-emissions-reduction-act-dera . [Accessed 22 September 2020].

toxic metal has a cancer potency factor and applies only to the fraction of the overall weight of the emissions that are associated with health effects of the metal.[11] The combined exposure factor accounts for the exposure factor for each assigned age bin. Each assigned age bin is made up of the daily breathing rate, exposure duration of the age bin, fraction of time at home, and an age sensitivity factor. The daily breathing rate is calculated using the California Air Resources Board (CARB) and California Air Pollution Control Officer Association's Risk Management Policy (RMP) Using the Derived Method methodology. The method assumes a 95th percentile breathing rate for children from the last trimester through age 2 and an 80th percentile daily breathing rate for other age groups. The multi-pathway adjustment factor is used to account for substances that may contribute to risk from exposure pathways other than inhalation, such as ingestion of soil or homegrown vegetables.[12] For chronic non-cancer risk calculations, the estimated or measured annual average levels for each pollutant were multiplied by the molecular weight adjustment factor and multi-pathway adjustment factor, and then divided by the applicable chronic REL to determine a hazard quotient. The hazard quotients are then summed for each target organ for all applicable toxic substances, and the maximum hazard quotient from all the target organ is reported as the hazard index. A hazard index of less than one indicates that non-cancer chronic risks are less than risk thresholds.

The potential cancer risk for a given substance is expressed as the incremental number of potential cancer cases that could be developed per million people, assuming that the population is exposed to the substance at a constant annual average concentration over a presumed 30-year period. These risks are usually presented in chances per million. For example, if the incremental air toxics cancer risks were estimated to be 100 per million, the probability of an individual developing cancer due to a lifetime exposure would be increased by a hundred in a million above background levels of cancer risk (e.g. based on other factors, such as age, diet, genetics, etc). This would predict an additional 100 cases of cancer in a population of a million people over a 70-year lifetime period.

Perspectives of Risk

There are many factors that contribute to cancer risks and other health risks, including environmental pollution, behavioral risk factors (e.g. cigarette smoking, sedentary lifestyle), social and economic factors (e.g. experiences of racism, social support, poverty, access to health care), genetic factors (e.g. specific genes that confer higher risk for certain diseases), and many others. To provide perspective, it is sometimes helpful to compare the risks estimated from assessments of environmental exposures to the overall rates of health effects in the general population. For example, it is estimated that in the U.S. population, the chances of developing

[11] California Office of Environmental Health Hazard Assessment, "Air Toxics Hot Spots Program Guidance Manual, Appendix L: OEHHA/ARB Approved Health Values for Use in Hot Spot Facility Risk Assessments," February 2015. [Online]. Available: https://oehha.ca.gov/media/downloads/crnr/2015gmappendiceslm.pdf . [Accessed 19 November 2020].

[12] South Coast Air Quality Management District, "Risk Assessment Procedures for Rules 1401, 1401.1, and 212," 1 September 2017. [Online]. Available: http://www.aqmd.gov/docs/default-source/permitting/rule-1401-risk-assessment/riskassessproc-v8-1.pdf?sfvrsn=12 . [Accessed February 2021].

cancer over a lifetime is 38.4%.[13] This translates into a risk of about 384,000 in a million over a lifetime. An estimated 19% of cancers in the United States are attributed to cigarette smoking, 4.7% are due to UV radiation, and 16.3% are related to excess body weight, alcohol intake, and physical inactivity.[14] These contributions of behavioral risk factors to cancer risk add up to 40%. Multiplying 40% by 384,000 indicates that approximately 153,600 in a million incidence of cancer over a lifetime may be related to these lifestyle risk factors. For comparison, the grid cell with the highest cumulative cancer risk from the pollutants in the MATES V is 1,141 in a million (see Chapter 4).

However, it is important to note that environmental risk factors such as outdoor air pollution deserve particular attention because they are involuntary risks and largely controlled by others. In other words, an individual cannot choose not to breathe air pollution in the neighborhood where they live, and that person often cannot make personal choices to directly reduce that air pollution. The health impacts of air pollution continues to be an important consideration, and reducing these involuntary risks helps to improve environmental equity in our communities.

Source of Uncertainty

The estimates of health risks are based on the state of current knowledge, and the process has undergone extensive scientific and public review. However, there is uncertainty associated with the processes of risk assessment. This uncertainty stems from the lack of data in many areas, which necessitate the use of assumptions. The assumptions are consistent with current scientific knowledge, but are often designed to be conservative and on the side of health protection in order to avoid underestimation of public health risks.

As noted in the 2015 OEHHA risk assessment guidance, sources of uncertainty, which may either overestimate or underestimate risk, include: (1) extrapolation of toxicity data in animals to humans, (2) uncertainty in the estimation of emissions, (3) uncertainty in the air dispersion models, and (4) uncertainty in the exposure estimates. Uncertainty may be defined as what is not known and may be reduced with further scientific studies. In addition to uncertainty, there is a natural range or variability in the human population in such properties as height, weight, and susceptibility to chemical toxicants.

Due to this uncertainty, the risk estimates should not be interpreted as actual rates of disease in the exposed population, but rather as estimates of potential risk, based on current knowledge and a number of assumptions. However, a consistent approach to risk assessment is useful to compare different sources and different substances to prioritize public health concerns.

Recognizing that science is never static, and that new data continues to emerge and enhance our understanding of the health effects of air pollution, we remain open to refining such evaluations as new knowledge becomes available. The MATES V study uses the most current OEHHA risk

[13] National Cancer Institute, "Cancer Statistics," 27 April 2018. [Online]. Available: https://www.cancer.gov/about-cancer/understanding/statistics . [Accessed 24 June 2020].

[14] F. Islami, A. G. Sauer, K. D. Miller, R. L. Siegel, S. A. Fedewa, E. J. Jacobs, M. L. McCullough, A. V. Patel, J. Ma, I. Soerjomataram, W. D. Flanders, O. W. Brawley, S. M. Gaps and J. Ahmedin, "Proportion and Number of Cancer Cases and Deaths Attributable to Potentially Modifiable Risk Factors in the United States," *CA: A Cancer Journal for Clinicians*, vol. 68, pp. 31-54, 2018.

assessment guidance (2015) to estimate health risks as well as other newer statistical methods that help provide a picture of air toxics in our jurisdiction using the best available science.

Determining Trends in Risk

Staff have updated the methods used for statistical calculations to be consistent with state-of-the-science methods. In particular, some pollutant concentrations are below the method detection limits, and staff followed guidance provided in Singh et al. (2006)[15], which is an in-depth U.S. EPA-commissioned report on the topic of handling environmental data below the detection limits and Helsel (2012)[16] for handling this type of data see Appendix XI for details.. Since this approach is different from the previous MATES, staff have re-analyzed MATES II through MATES IV data using consistent methods for all data that were available. This allows direct comparison of concentrations over time and allows the determination of trends in concentration and risk. For the risk estimates based on modeling data, staff used the model output from prior MATES iterations and applied the methods from the most current (2015) OEHHA risk assessment guidelines.

[15] A. Singh, R. Maichle, Lee and S. E, "On the Computation of a 95% Upper Confidence Limit of Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations," US EPA, Washington DC, 2006.
[16] D. Helsel, Statistics for Censored Environmental Data Using Minitab and R, 2nd ed., Hoboken, New Jersey: John Wiley & Sons, Inc., 2012.